Center for Nanoscale Materials

A Nanoscale Science Research Center of the U.S. Department of Energy

Challenge

The National Nanotechnology Initiative is an interagency effort driven by the realization that present-day materials and processes are reaching their performance limits. Fundamentally new types of functional materials will be needed in the near future so industry and society as a whole can continue to prosper.

Argonne's Role

Argonne's Center for Nanoscale Materials (CNM) (Figure 1) will help advance the basic science behind nanotechnology and spur the development of products based on nanomaterials. New technologies and new industries can emerge from CNM's basic explorations.

As one of a new generation of the U.S. Department of Energy's (DOE's) research and user facilities, CNM's primary goal is to fabricate advanced nanoscale materials. Sophisticated probes will be available for materials characterization (Figure 2), and a "Virtual Fab Lab" is envisioned that would use large-scale computer modeling to simulate the creation of new quantum materials.

Figure 1. The new Center for Nanoscale Materials will be adjacent to Argonne's Advanced Photon Source.

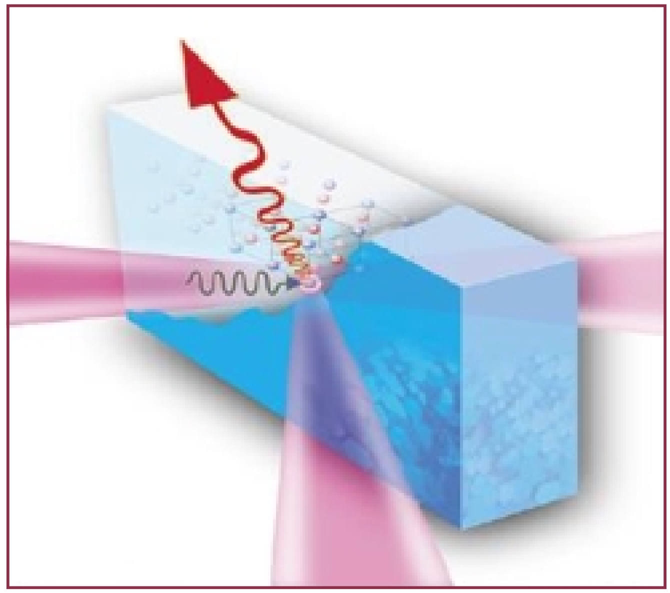

Figure 2. The CNM's hard x-ray nanoprobe will focus down to an unprecedented resolution of 30 nanometers, allowing researchers to characterize the structural properties of nanostructures.

The CNM is the focal point for a variety of scientific collaborations with academia, industry, and other government laboratories that will broaden the user community throughout the nation. It will support all stages of nanoscale materials research and development, from synthesis and patterning through metrology, compositional and structural determinations, and characterization of physical phenomena.

Developing New Processes

Molecular Self-Assembly ("bottom-up" fabrication): Chemical processes create nanoscale devices. Self-assembly is, in some respects, similar to the way biological systems put molecules in a hierarchical structure with enhanced functionality and complexity.

Nanolithography ("top-down" fabrication): Etching, writing, sculpting, or printing create low-dimensional devices having features measured in nanometers.

Developing New Instrumentation

Nanofabrication: Electron lithography and focused-ion-beam lithography equipment will be used to fabricate nanostructures. Additional nanofabrication tools will be available for etching, deposition, and other processes.

Nanocharacterization: Argonne will develop tools for visualizing nanostructures, including specialized equipment such as a dedicated hard x-ray nanoprobe beamline at the Advanced Photon Source.

Exploring New Areas of Research

Figure 3 shows the five primary areas of research for Argonne's CNM. Each is described below.

Nanomagnetism: Methods of chemical self-assembly, as well as lithographic patterning of thin-film hybrid systems, are used to create new nanostructures. The technique of using the spin (magnetism) of an electron, in addition to its charge, is opening the new field of magnetic electronics or "spintronics."

Bio-Inorganics: Bridging the interface between soft matter (complex organic and biological molecules) and hard matter (solid-state nanoparticles and patterned systems) generates new materials. The electronic properties of soft and hard matter are coupled to create materials that combine the responsiveness of biological molecules with the robustness and electronic addressability of inorganic materials.

Nanocrystalline Diamond: Argonne's nanocrystalline diamond films are smooth, dense, and phase-pure. They can be conformally coated on a wide variety of materials and high-aspect-ratio structures. Researchers worldwide are using the films to develop micro-electromechanical systems (MEMS) and other devices that are 1,000 times more wear-resistant than those made of silicon.

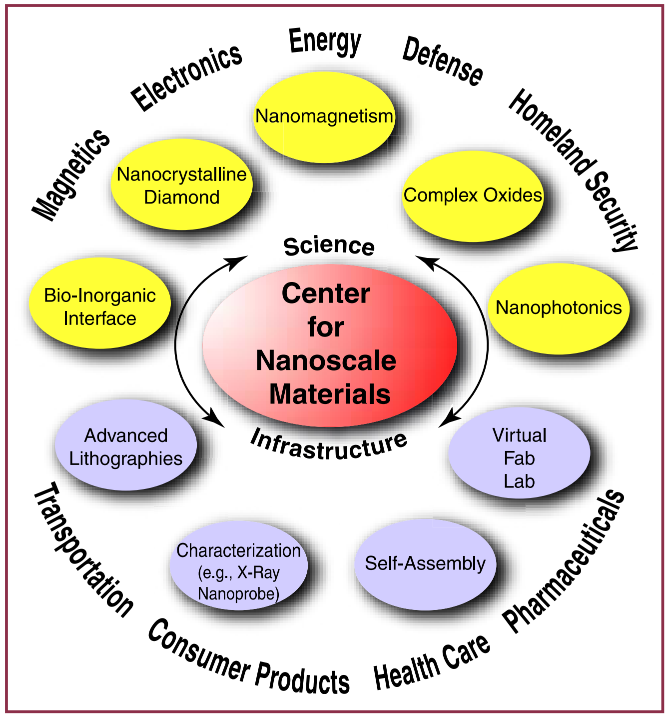

Figure 3. Argonne's Center for Nanoscale Materials will initially be organized around five primary areas of research (shown in yellow).

Complex Oxides: As film thickness and feature size decrease in existing devices, new thin-film materials, device structures, and complex processing conditions will be required. Researchers will explore novel fabrication methods and seek to understand and control the synthesis of nanoferroelectrics, spin-polarized oxides, and multiferroics.

Nanophotonics: The decreasing size of optical devices requires extending the power of optics to the nanometer scale. Control and manipulation of light at this scale requires a new generation of miniature optical (photonic) devices that process light without being physically limited by the fundamental length scales corresponding to the light's wavelength.

Sponsors

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